

Appl. No. 10/047,454

PATENT

Amendment dated September 7, 2005

Amendment under 37 CFR 1.116 Expedited Procedure Examining Group 2878

Response to Office Action dated February 11, 2005

Amendments to the Claims:

Please cancel claims 30 and 33-36; and amend claims 29, 37, 38, and 39.

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Previously presented) A scanning probe microscope assembly for examining an object, comprising:

a probe having a tip with a sharp end;

means for inducing and detecting non-optical interaction of said tip and said object, said non-optical interaction being other than a tunneling current between said tip and said object;

a light source optically coupled to said tip for providing light to said tip;

said tip being shaped to emit light resulting from said provided light at said sharp end so that said emitted light optically interacts with said object, wherein said tip is shaped to capture light resulting from said emitted light optically interacting with said object; and

a photodetector that is optically coupled to said tip for detecting said captured light.

2. (Original) A scanning probe microscope assembly as recited in claim 1 wherein:

said probe includes a cantilever connected to said tip; and

said non-optical interaction inducing and detecting means includes means for inducing atomic force interaction between said tip and said object and for detecting deflection of said cantilever due to said atomic force interaction.

3. (Previously presented) A scanning probe microscope assembly as recited in claim 1 wherein said non-optical interaction inducing and detecting means includes, in addition to said means for inducing and detecting non-optical interaction that is other than a tunneling

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current between said tip and said object, means for inducing and detecting a tunneling current between said tip and said object.

4. (Original) A scanning probe microscope assembly as recited in claim 1 further comprising a spectrophotometer including said light source and said photodetector for making spectrophotometric measurements of said resulting light.

5. (Original) A scanning probe microscope assembly as recited in claim 1 wherein:

said tip has a base; and

said scanning probe microscope assembly further comprises a lens disposed over said tip and optically coupled between said light source and said tip for focusing said provided light in said base of said tip.

6. (Original) A scanning probe microscope assembly as recited in claim 5 wherein said lens is a fresnel lens.

7. (Previously presented) A scanning probe microscope assembly for examining an object, comprising:

a probe having a tip with a sharp end and a base;

means for inducing and detecting non-optical interaction of said tip and said object, said non-optical interaction being other than a tunneling current between said tip and said object;

a light source optically coupled to said tip for providing light to said tip;

a fresnel lens that is formed in said probe over said tip for focusing said provided light in said base of said tip;

said tip being shaped to emit light resulting from said provided light at said sharp end so that said emitted light optically interacts with said object; and

a photodetector for detecting light resulting from said emitted light optically interacting with said object.

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8. (Original) A scanning probe microscope assembly as recited in claim 5 wherein said lens is a refractive lens.

9. (Canceled)

10. (Previously presented) A scanning probe microscope assembly as recited in claim 1 wherein:

said tip has a base; and

said scanning probe microscope assembly further comprises a lens disposed over said tip and optically coupled between said light source and said tip for focusing said provided light in said base of said tip, said lens also optically coupled between said tip and said photodetector for focusing said captured light for detection by said photodetector.

11. (Original) A scanning probe microscope assembly as recited in claim 10 further comprising means for directing said provided light to said lens and for directing said focused captured light to said photodetector.

12. (Original) A scanning probe microscope assembly as recited in claim 11 wherein said directing means includes a fiber optic light guide optically coupled between said light source and said lens and between said photodetector and said lens.

13. (Previously presented) A scanning probe microscope assembly for examining an object, comprising:

a probe having a tip with a sharp end wherein said tip includes a core material transparent to said provided light and an obdurate layer transparent to said provided light over said core material at least at said sharp end;

means for inducing and detecting non-optical interaction of said tip and said object, said non-optical interaction being other than a tunneling current between said tip and said object;

a light source optically coupled to said tip for providing light to said tip;

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said tip being shaped to emit light resulting from said provided light at said sharp end so that said emitted light optically interacts with said object; and

a photodetector that is optically coupled to said tip for detecting light resulting from said emitted light optically interacting with said object.

14. (Original) A scanning probe microscope assembly as recited in claim 13 wherein said obdurate layer comprises diamond oriented normal to the surface of said core material.

15. (Original) A scanning probe microscope assembly as recited in claim 13 wherein said obdurate layer comprises silicon carbide.

16. (Original) A scanning probe microscope assembly as recited in claim 15 wherein said silicon carbide is doped to be conductive.

17. (Original) A scanning probe microscope assembly as recited in claim 13 wherein said obdurate layer comprises carbon nitride.

18. (Original) A scanning probe microscope assembly as recited in claim 13 wherein said obdurate layer comprises tungsten.

19. (Previously presented) A scanning probe microscope assembly for examining an object, comprising:

a probe having a tip with a sharp end;

means for inducing and detecting non-optical interaction of said tip and said object;

a light source optically coupled to said tip for providing light to said tip wherein said tip includes a core material transparent to said provided light and a light-emissive coating over said core material at said sharp end, which light-emissive coating emits light in response to said provided light;

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said tip being shaped at said sharp end so that emitted light from said light-emissive coating optically interacts with said object; and

a photodetector for detecting light resulting from said emitted light optically interacting with said object.

20. (Previously presented) A scanning probe microscope assembly for examining an object, comprising:

a probe having a tip with a sharp end;

means for inducing and detecting non-optical interaction of said tip and said object;

a light source optically coupled to said tip for providing light to said tip wherein said tip includes a core material transparent to said provided light and a frequency-doubling coating over said core material at said sharp end, which frequency-doubling coating emits light, referred to as emitted light, in response to said provided light;

said tip being shaped at said sharp end so that emitted light from said frequency-doubling coating optically interacts with said object; and

a photodetector for detecting light resulting from said emitted light optically interacting with said object.

21. (Previously presented) A scanning probe microscope assembly as recited in claim 1 wherein said photodetector includes a photodiode formed in said tip for detecting said captured light.

22. (Original) A scanning probe microscope assembly as recited in claim 21 wherein:

said photodiode comprises:

a first doped silicon region in said tip;

a second doped silicon region in said tip oppositely doped to and in contact with said first doped region;

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a first conductive region in contact with said first doped region;
a second conductive region in contact with said second doped region;
said photodetector further comprises a photodiode measurement circuit coupled across said first and second conductive regions for making measurements of said captured light detected by said photodiode.

23. (Previously presented) A scanning probe microscope assembly for examining an object, comprising:

a probe having a tip, said tip including:
a core material with a sharp end;
a light emissive layer over at least a portion of said core material; and
a conductive layer over said light emissive layer but not over said core material at said sharp end;

means for applying a voltage between said conductive layer and said core material so that said light emissive layer emits light within said probe that propagates through said probe and is emitted at said sharp end, said emitted light optically interacting with said object; and
a photodetector for detecting light resulting from said emitted light optically interacting with said object.

24. (Original) A scanning probe microscope assembly as recited in claim 23 wherein:

said probe includes a cantilever connected to said tip; and
said scanning probe microscope assembly further comprises means for inducing atomic force interaction between said tip and said object and for detecting deflection of said cantilever due to said atomic force interaction.

25. (Original) A scanning probe microscope assembly as recited in claim 23 further comprising means for inducing and detecting a tunneling current between said tip and said object.

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26. (Original) A scanning probe microscope assembly as recited in claim 23 wherein said emissive layer comprises gallium nitride.

27. (Original) A scanning probe microscope assembly as recited in claim 23 wherein said emissive layer comprises gallium arsenide.

28. (Original) A scanning probe microscope assembly as recited in claim 23 wherein said emissive layer comprises silicon carbide doped to be emissive.

29. (Currently amended) A method of operating a scanning probe microscope for examining an object, said scanning probe microscope having a probe that includes a base, a cantilever connected to said base, and a tip connected to said cantilever, said scanning probe microscope assembly having a tunneling current mode and an atomic force mode, said the method comprising:

inducing and detecting a tunneling current between said tip and said object during said tunneling current mode;

inducing atomic force interaction between said tip and said object and detecting deflection of said cantilever due to said atomic force interaction during said atomic force mode; and

immobilizing said tip with respect to said base so as to prevent said tip from moving toward or away from said object during said tunneling current ~~mode~~ mode, wherein:

said cantilever has a lower surface to which said tip is connected and an upper surface; and

said immobilizing said tip with respect to said base is accomplished by:

a member disposed over said upper surface of said cantilever;

a first coil on said upper surface of said cantilever;

a second coil on said lower surface of said member; and

producing currents in said coils to magnetically immobilize said tip with respect to said base during said tunneling current mode.

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30. (Canceled).

31. (Previously presented) A method of operating a scanning probe microscope for examining an object wherein

said scanning probe microscope has a probe that includes a base, a cantilever connected to said base, and a tip connected to said cantilever,

said cantilever has a free end adjacent to said tip, and

said scanning probe microscope assembly has a tunneling current mode and an atomic force mode,

the method comprising:

inducing and detecting a tunneling current between said tip and said object during said tunneling current mode;

inducing atomic force interaction between said tip and said object and detecting deflection of said cantilever due to said atomic force interaction during said atomic force mode;

providing a clamping structure having a clamping arm connected to said base, said clamping arm extending from said base and having a free end extending past and opposing said free end of said cantilever; and

controlling movement of said free end of said clamping arm against said free end of said cantilever during said tunneling mode to immobilize said tip with respect to said base.

32. (Previously presented) A method of operating a scanning probe microscope for examining an object wherein

said scanning probe microscope has a probe that includes a base, a cantilever connected to said base, and a tip connected to said cantilever,

said cantilever has a free end adjacent to said tip, and

said scanning probe microscope assembly has a tunneling current mode and an atomic force mode,

the method comprising:

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inducing and detecting a tunneling current between said tip and said object during said tunneling current mode;

inducing atomic force interaction between said tip and said object and detecting deflection of said cantilever due to said atomic force interaction during said atomic force mode;

providing a clamping structure that surrounds said cantilever and includes clamping arms; and

controlling movement of said clamping arms against said cantilever during said tunneling mode to immobilize said tip with respect to said base.

33-36. (Canceled).

37. (Currently amended) A method ~~as recited in claim 29~~ of operating a scanning probe microscope for examining an object, said scanning probe microscope having a probe that includes a base, a cantilever connected to said base, and a tip connected to said cantilever, said scanning probe microscope assembly having a tunneling current mode and an atomic force mode, the method comprising:

inducing and detecting a tunneling current between said tip and said object during said tunneling current mode;

inducing atomic force interaction between said tip and said object and detecting deflection of said cantilever due to said atomic force interaction during said atomic force mode;
and

immobilizing said tip with respect to said base so as to prevent said tip from moving toward or away from said object during said tunneling current mode, wherein:

wherein said cantilever has a lower surface to which said tip is connected and an upper surface; and

said immobilizing said tip with respect to said base is accomplished by:
providing a member disposed over said upper surface of said cantilever;
providing a permanent magnet on said upper surface of said cantilever;
providing a coil on said lower surface of said member; and

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producing a current in said coil to magnetically immobilize said tip with respect to said base during said tunneling current mode.

38. (Currently amended) A method as recited in claim 29 of operating a scanning probe microscope for examining an object, said scanning probe microscope having a probe that includes a base, a cantilever connected to said base, and a tip connected to said cantilever, said scanning probe microscope assembly having a tunneling current mode and an atomic force mode, the method comprising:

inducing and detecting a tunneling current between said tip and said object during said tunneling current mode;

inducing atomic force interaction between said tip and said object and detecting deflection of said cantilever due to said atomic force interaction during said atomic force mode;
and

immobilizing said tip with respect to said base so as to prevent said tip from moving toward or away from said object during said tunneling current mode, wherein:

wherein said cantilever has a lower surface to which said tip is connected and an upper surface; and

said immobilizing said tip with respect to said base is accomplished by:

providing an element coupled to said base having a lower surface disposed over said upper surface of said cantilever;

providing a permanent magnet on said lower surface of said element;

providing a coil on said upper surface of said cantilever; and

producing a current in said coil to magnetically hold said cantilever rigid with respect to said base during said tunneling current mode.

39. (Currently amended) A method as recited in claim 29 of operating a scanning probe microscope for examining an object, said scanning probe microscope having a probe that includes a base, a cantilever connected to said base, and a tip connected to said cantilever, said scanning probe microscope assembly having a tunneling current mode, an atomic force mode,

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and ~~wherein said scanning probe microscope assembly also has a spectrophotometry mode and the method further comprises:~~ mode, the method comprising:

inducing and detecting a tunneling current between said tip and said object during said tunneling current mode;

inducing atomic force interaction between said tip and said object and detecting deflection of said cantilever due to said atomic force interaction during said atomic force mode;

immobilizing said tip with respect to said base so as to prevent said tip from moving toward or away from said object during said tunneling current mode;

providing a spectrophotometer including a light source optically coupled to said tip;

controlling said light source to provide light to said tip during said spectrophotometry mode;

said tip being shaped to emit said provided light at said sharp end so that said emitted light optically interacts with said object; and

detecting light that results from said emitted light optically interacting with said object to make spectrophotometric measurements of said detected light.

40. (Previously presented) A scanning probe microscope assembly for examining an object wherein said scanning probe microscope assembly has a near-field optical mode and at least one of a tunneling current mode and an atomic force mode, said scanning probe microscope assembly comprising:

a probe having a tip with a sharp end;

a light source optically coupled to said tip;

means for controlling said light source to provide light to said tip during said near-field optical mode;

rotationally polarizing means for rotationally polarizing said provided light;

means for controlling said rotationally polarizing means to rotationally polarize said provided light during said near-field optical mode;

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a photodetector for detecting light that results from said emitted light optically interacting with said object; and

deep surface feature analysis means coupled to said photodetector for identifying deep surface features based on said resulting light detected by said photodetector during said near-field optical mode.

41. (Previously presented) A scanning probe microscope assembly for examining an object wherein said scanning probe microscope assembly has a hardness testing mode and at least one of a tunneling current mode and an atomic force mode, said scanning probe microscope assembly comprising:

a probe having a tip with a sharp end;

a light source optically coupled to said tip;

directing means for directing said tip to penetrate said object at a specific point with a predefined known force;

means for controlling said light source to provide light to said tip during said hardness testing mode before and after said tip penetrates said object;

said tip emitting at said sharp end said light provided before and while said tip penetrates said object so that said emitted light optically interacts with said object before and while said tip penetrates said object;

a photodetector, said photodetector detecting light resulting from said emitted light optically interacting with said object before and while said tip penetrates said object; and

comparing means for comparing said resulting light detected before said tip penetrates said object with said resulting light detected while said tip penetrates said object to determine the hardness of said object.

42. (Previously presented) A scanning probe microscope assembly for examining an object wherein said scanning probe microscope assembly has a hardness testing mode and at least one of a tunneling current mode and an atomic force mode, said scanning probe microscope assembly comprising:

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a probe having a tip with a sharp end;

means for directing said tip to penetrate said object at a specific point with a predefined known force; and

means for measuring the conductivity of said object before and while said tip penetrates said object to determine the hardness of said object.

43 - 54. (Canceled).

55. (Previously presented) A scanning probe microscope assembly for examining an object, comprising:

a probe that includes

a base,

a cantilever connected to said base, and

a tip having a sharp end, said tip connected to said cantilever;

atomic force means for inducing atomic force interaction between said tip and said object and for detecting deflection of said cantilever due to said atomic force interaction during said atomic force mode;

tunneling current means for inducing and detecting a tunneling current between said tip and said object during a tunneling current mode;

holding means for immobilizing said tip with respect to said base during said tunneling current mode;

a light source optically coupled to said tip for providing light to said tip;

said tip being shaped to emit light resulting from said provided light at said sharp end so that said emitted light optically interacts with said object; and

a photodetector for detecting light resulting from said emitted light optically interacting with said object.

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56. (Previously presented) A scanning probe microscope assembly as recited in claim 1 wherein said emitted light is light that results from said provided light being transmitted through said tip.

57. (Previously presented) A scanning probe microscope assembly as recited in claim 1 wherein said emitted light is light emitted by a coating on said sharp end of said tip that results from an interaction between said provided light and said coating.